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ESTIMATED BREEDING VALUE OF PRE-WEANING GROWTH TRAITS IN THE SIMMENTAL CATTLE OF INDONESIA

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Abstract – Simmental cattle (*Bos taurus*) is one of the beef cattle breed that has high value of meat production. This research was carried out to calculate Estimated Breeding Value (EBV) of pre-weaning growth traits in Simmental cattle at the breeding station. The records data of birth and weaning weights from year 2012 to 2017 were used in this study. Research showed that the average of corrected birth weight (BW_C), weaning weight at 205 days of age (WW_{205}) and average daily gain (ADG) in animals study were 42.82±6.24 kg; 193.69±40.45 kg and 0.74±0.19 kg/day respectively. Hence, the heritability (h^2) value of BW_C; WW_{205} and ADG were 0.84±0.33; 0.81±0.32 and 0.70±0.30 respectively. The highest of cumulative estimated breeding value for sire (EBV_{Sire}) was +61.31kg (Bull ID: W. Drovin). Meanwhile, the highest of cumulative estimated breeding value for progeny (EBV_{Prog}) in male calf was +86.86 kg (Calf ID: 000354) and in female calf was +79.01 kg (Calf ID: 000435). It was concluded that BW, WW and ADG traits had highly of h^2 value (h^2>0.30) and indicating that both traits can be increased through selection program.

INTRODUCTION

Simmental cattle is one of the beef cattle breeds that originated from Switzerland. This cattle is famous in the world and had highly of meat production. In Indonesia, this cattle was imported by the government since year 1974. Recently, the selection program for Simmental cattle in Indonesia was performed by Bureau of Breeding and Forage Center in Padang Mengatas. Selection in Simmental cattle at the breeding station can be maintained with conventional method. Hence, selection in the livestock with this method can be maintained in the breeding farm with good recording management. In beef cattle selection, records data of body weight and average daily gain were very important (Supriyantono *et al.*, 2011). In the conventional method, selection of livestock can be conducted based on estimated breeding value (EBV). Therefore, the heritability (h^2) estimation is very important in the conventional selection to obtain EBV.

In the conventional selection, h^2 value was used to describe the level of phenotypic variation among individuals. The h^2 value was consisted of three category of low (h^2<0.10), moderate (0.11<h^2<0.30) and high (h^2>0.30) as stated by Falconer and Mackay (1996). A trait with high of h^2 value indicated that the phenotypic variation among individu was high and this trait can be improved through conventional selection mainly based on EBV parameter. Previous studies reported that the conventional selection was performed in many native cattle breeds in Indonesia such as Bali, Brahman, Aceh, Sumba Ongole (SO), Ongole grade (PO) and Madura (Supriyantono *et al.*, 2010; Rastosari *et al.*, 2014; Putra e*t al.*, 2015; Said *et al.*, 2016; Sumadi *et al.*, 2017; Prihandini *et al.*, 2018).

The selection program for Simmental cattle in Indonesia is important to increase the productive traits of cattle. This study was carried out to select the best Simmental cattle reared at Bureau of Breeding and Forage Center (BBFC) Padang Mengatas based on EBV of pre-weaning growth traits. Therefore, the findings in this study can be applied in BBFC Padang Mengatas to obtain the best Simmental cattle based on the their parents performances.

MATERIALS AND METHODS

Place and Samples

The records data of birth weight (BW) and weaning weight (WW) in Simmental cattle (year 2012 to 2017) were collected from Bureau of Breeding and Forage Center in Padang Mengatas (BPTU-HPT Padang Mengatas) at West Sumatera province of Indonesia. Unfortunately, the dam's age was not clearly recorded in the herd book. This area was located between latitude 0°25"28.71" N to 0°22"14.52 S and longitude 100°15"44.10" E to 100°50"47.80" E. The maximum temperature in research site ranged between 18 °C to 28 °C with humidity about 70 % with rainfall about 1800 mm/year and 700 m to 900 m above the sea surface.

Management of Animals

The Simmental cattle at breeding station were kept with three management systems of extensive, intensive and semi-intensive. The grasses that planted in the pasture field consisted of *Brachiaria decumbens, Brachiaria humidicola, Chloris gayana, Panicum maximum, Pennisetum purpureum, Setaria sphacelata* and *Pennisetum purpureophoides*. Meanwhile, the legume trees in the pasture field consisted of *Stylosanthes guianensis, Centrocema pubescens, Indigofera sp, Sesbania grandiflora* and *Desmodium cinerea.* Thus, the mixture concentrate (matery feed) was given to animals and consisted of rice bran (40%), commercial concentrate (40%), coconut cake (16%), cattle mix (2%) and salt (2%). According to the proximate analysis, the matery feed containing of water (9.58%), ash (10.16%), crude protein (13.85%), crude fat (5.47%), crude fiber (22.26%), calcium (0.55%) and phosphor (0.55%). In addition, the urea mineral molases block (UMMB) was mantained in the research site and was made from starch (15%), rice bran (33%), coconut cake (1%), urea (3%), salt (10%), chalk (5%), mineral (13%), molases (10%) and cement (10%). The matery feed was given to each cattle one time a day (08.00 am) with 3% from their body weight. Thus, the UMMB was taken in the pasture field and colony stall. The water was given by ad libitum in the pasture field and colony stall. Thus, pregnancy and health examinations were performed every month. Two mating systems of artificial insemination (AI) and natural mating were managed in the research site.

Data Analysis

The correction factor of sex (CF_{Sex}) were conducted in birth weight based on Hardjosubroto (1994) as follows:

$$CF_{Sex} = \frac{\text{Average of body weight in male calves}}{\text{Average of body weight in female calves}}$$

Data of WW was corrected at 205 days of age using formula according to Hardjosubroto (1994) as follows:

$$WW_{205} = \left(\frac{WW - BW}{T} \times 205 \right) + BW_C$$

Where, WW_{205} is the weaning weight at 205 days of age; WW is the actual weaning weight; BW is the actual birth weight; BW_C is the corrected birth weight and T is the duration time between birth to weaned.

The average daily gain (ADG) was calculated using formula according to Hardjosubroto (1994) as follows:

$$ADG = \frac{WW - BW}{T}$$

Where, ADG is the average daily gain; WW is the actual weaning weight; BW is the actual birth weight; and T is the duration time between birth to weaned.

The heritability (h^2) value was analyzed using paternal halfshib correlation model through analysis of variance (ANOVA) method with a mathematical model according to Becker (1992) as follows:

$Y_{ik} = \mu + a_i + e_{ik}$

Where, Y_{ik} is the observation of trait; μ is the common mean; a_i is the effect of i^{th} sire; and e_{ik} is the experimental error. Therefore, the h^2 value was estimated using formula according to Becker (1992) as follows:

$h^2 = 4t$

$$t = \frac{\sigma_S^2}{\sigma_S^2 + \sigma_W^2}$$

$$SE(h^2) = 4\sqrt{\frac{2(1-t)^2[1+(k-1)t]^2}{k(k-1)(S-1)}}$$

$$k = \frac{1}{S-1}\left(N - \frac{\sum n_i^2}{N} \right)$$

Where h^2 is the heritability value; σ_S^2 is the variance component of sire; σ_W^2 is the variance component of individu; $SE(h^2)$ is the standard error of heritability; S is the number of sire; n_i is the

number of progeny per sire; and N is the total number of progeny.

The relative estimated breeding value (EBV) of birth weight was analyzed using mathematics formula according to Hardjosubroto (1994) as follows:

$$EBV_{Sire} = \frac{2\,n\,h^2}{4+(n-1)h^2}\left(\overline{P}_{prog} - \overline{P}_{pop}\right)$$

$$EBV_{Prog} = h^2\left(P_{ind} - \overline{P}_{pop}\right)$$

Where EBV_{Sire} is the estimated breeding value for sire; EBV_{Prog} is the estimated breeding value for progeny; h^2 is the heritability value; $\overline{P}_{Prog}$ is the mean of trait in progeny; $\overline{P}_{Pop}$ is the mean of trait in population; and P_{ind} is the trait of individu.

The relative accuration (RA) calculation was performed in this study to measure the accuracy of selection for bulls using mathematical formula according to Hardjosubroto (1994) as follows:

$$RA = (0.50)\sqrt{\frac{n}{1+(n-1)t}}$$

$$t = Rh^2$$

Where RA is the relative accuracy; n is the number of progeny per sire; and R is 0.25 (halfsib correlation)

RESULTS

The pre-weaning growth traits of Simmental cattle was presented in Table 1. The average of pre-weaning growth traits in male cattle were 42.78±6.14 kg (BW), 197.69±41.62 kg (WW) and 0.76±0.19 kg/day (ADG) respectively. Meanwhile the average of pre-weaning growth traits in female cattle were 40.79±6.03 kg (BW), 186.21±40.06 kg (WW) and 0.71±0.18 kg/day (ADG) respectively. In this study, the effect of sex in BW_C, WW_{205} and ADG were not observed. In addition, the average of actual BW, WW and ADG in total animals were 41.87±6.17 kg (BW), 192.44±41.28 kg (WW) and 0.74±0.19 kg/day (ADG). The average of ADG based on actual data and corrected data in this study were showed similar values. The h^2 values of pre-weaning growth traits in Simmental cattle were presented in Table 2. The h^2 value of BW_C, WW_{205} and ADG in this study were 0.84±0.33; 0.81±0.32 and 0.70±0.30 respectively. The EBV_{Sire} of pre-weaning growth traits in Simmental bulls was presented in Table 3. The EBV_{Sire} in Simmental bulls were ranged into -17.51 to +6.54 kg (BW_C), -80.72 to +60.93 kg (WW_{205}) and -0.30 to +0.28 kg/day (ADG). The cumulative EBV_{Sire} was ranged from -98.53 (Bull ID: Simm Aussy) to +61.31 (Bull ID: W. Drovin). The second the best Simmental bull was reached by bull ID: W. Dermont with cumulative EBV_{Sire} reached of +56.05 (Figure 1). The EBV_{Prog} of pre-weaning growth traits in Simmental

Table 1. Descriptive statistics of pre-weaning growth traits in Simmental cattle at the breeding station

Parameters	BW (N)	WW (N)	ADG (N)
Sex			
Male	42.78±6.14 (319)	197.69±41.62 (316)	0.76±0.19 (310)
Female	40.79±6.03 (270)	186.21±40.06 (266)	0.71±0.18 (264)
Total			
Actual	41.87±6.17 (589)	192.44±41.28 (582)	0.74±0.19 (574)
Corrected*	42.82±6.24 (589)	193.69±40.45 (575)	-

BW: birth weight (kg); WW: weaning weight (kg); ADG: average daily gain (kg/day); N: number of observation

Table 2. Variance components to estimate heritability value of pre-weaning growth traits in Simmental cattle at the breeding station

Traits	NS	N	k	σ_s^2	σ_w^2	h2±SE
Birth weight*	12	343	28.42	5.12	19.39	0.84±0.33
Weaning weight*	12	336	25.53	273.40	1078.40	0.81±0.32
Average daily gain	12	336	25.53	0.005	0.02	0.70±0.30

*Estimated with corrected data; NS: number of sire; N: number of progeny; k: constanta; σ_s^2: variance component of sire; σ_w^2: variance component of individu; h2: heritability; SE: standard error

Bull ID	W. Dermont (60877)
Date of birth	17/07/2008
Origin	Australia
Sire	Waterfront Admorality
Dam	Waterfront Victory
Body weight	920 kg
Heart girth	230 cm
Body length	181 cm
Withers height	151 cm

Fig. 1. The performance of second best Simmental bull (*Source:* Bureau of Artificial Insemination in Lembang, Indonesia)

cattle were presented in Table 4. The highest EBV_{Prog} of BW_C, WW_{205} and ADG in male cattle were +8.02 kg (Calf ID: 000434), +88.46 kg (Calf ID: 000354) and +0.38 kg/day (Calf ID: 000354). Meanwhile, the highest EBV_{Prog} of BW_C, WW_{205} and ADG in female cattle were +14.72 kg (Calf ID: 22.05.17), +70.32 (Calf ID: 000435) and +0.27 (Calf ID: 000435). Meanwhile, the highest cumulative EBV_{Prog} in male and female cattle were +86.86 (Calf ID: 000354) and +79.01 (Calf ID: 000435). The RA values in this study were ranged from 0.78 to 1.06 (BW_C), 0.79 to 1.07 (WW_{205}) and 0.81 to 1.16 (ADG).

DISCUSSION

Research showed that the pre-weaning growth traits in male cattle were higher than in female animal but not significantly different. Previous studies reported that no effect of sex were reported in the BW_C and WW_{205} of many cattle breeds such as Friesian Holstein (Bakir *et al.*, 2004), Fogera cross (Addisu *et al.*, 2010), Bali (Gunawan and Jakaria, 2011), Horro (Abera e*t al.*, 2013) and Friesian cross (Rahman *et al.*, 2015). However, the mechanism of sex hormonal (androgen) in the male cattle was caused higher in pre-weaning growth traits as reported by Soeparno (2005). The h^2 value of BW_C in animals study was included of high category and similar to Red Chittagong (0.50), Horro (0.62), Nellore (0.37), Bali (0.85), Brahman (0.57) and Bonsmara (0.36), Friesian Holstein (0.40) and Sumba Ongole (0.66) cattle (Afroz *et al.*, 2011; Abera *et al.*, 2013; Regatieri e*t al.*, 2012; Kaswati *et al.*, 2013; Rakwadi *et al.*, 2014; Rahman *et al.*, 2015; Putra *et al.*, 2018). Thus, the h^2 value of WW_{205} in animals study was included of high category and similar to Wakwa (0.32), Charolais (0.36), Romosinuano (0.34), Madura (0.87), Tswana (0.37), Red Chittagong (0.50), Nellore (0.33), Bali (0.51), Brahman (0.53), Bonsmara (0.69), Tuli (0.36), Ongole grade (0.47), Aceh (0.48) and Sumba Ongole (0.65) cattle (Ebangi *et al.*, 2002; El-Saied *et al.*, 2006; Sarmiento and Garcia, 2007; Karnaen, 2008; Raphaka, 2008; Afroz *et al.*, 2011; Regatieri *et al.*, 2012; Kaswati *et al.*, 2013; Rakwadi *et al.*, 2014; Hartati *et al.*, 2015; Putra *et al.*, 2015; Putra *et al.*, 2018). Meanwhile, the h^2 value of ADG in animals study was included of high category and similar to Romosinuano (0.32), Madura (0.55), Tswana (0.34), Red Chittagong (0.48) and Sumba Ongole (0.68) cattle (Sarmiento and Garcia, 2007; Karnaen, 2008; Raphaka, 2008; Afroz *et al.*, 2011; Putra *et al.*, 2018).

The h^2 values in the present study were included of high category and suggest that the selection of Simmental cattle can be conducted based on pre-weaning growth traits. In other hand, selection based on pre-weaning growth traits mainly WW_{205} will be effective to increase the gain of this trait. Moreover, the weaning and yearling weights had highly of genetic correlation (Warwick *et al.*, 1990). Meanwhile, the SE estimation for each h^2 value were lower than h^2 value and suggest that the h^2 estimation in this study was accurate. The variation of h^2 value in this study compared to previous studies might be due to different of breeds, environment, number of data structure and statistical analysis used for estimation (Pattie and James, 1985).

The highest of EBV_{sire} for BW in this study was +6.54 (Bull ID: Domino) and shows higher than Brahman (+2.16 kg), Friesian Holstein (+2.99 kg) and Aceh (+0.06 kg) bulls (Tumwasorn, 1997; Atil *et al.*, 2005; Putra *et al.*, 2015). Meanwhile, the highest of EBV_{Sire} for WW in this study was +60.93 kg (Bull ID: W. Drovin) and shows higher than Friesian Holstein (+4.47 kg), Aceh (+6.44 kg), Ongole grade (+49.76 kg) and Madura (+6.61 kg) bulls. (Atil *et al.*, 2005; Putra *et al.*, 2015; Sumadi *et al.*, 2017; Prihandini *et al.*, 2018). The highest of EBV_{Prog} for BW in this study was +14.72 kg (Calf ID: 22.05.17) and shows higher than Friesian Holstein (+4.11 kg), Northeastern Thai

Table 3. Estimated breeding value of pre-weaning growth traits in the Simmental bulls at the breeding station

Rank	Bull ID	N	Average of progeny traits			EBV_{Sire}				RA			Remark
			BW_C	WW_{205}	ADG	BW_C	WW_{205}	ADG	Cumulative	BW_C	WW_{205}	ADG	
1	W. Drovin	88	42.87	225.52	0.89	+0.10	+60.93	+0.28	+61.31	1.07	1.09	1.16	Accurate
-	Ankonion	8	40.34	235.51	0.97	-3.37	+56.05	+0.29	+52.96	0.90	0.91	0.95	Not accurate
2	W. Dermont	26	43.64	215.56	0.84	+1.43	+37.99	+0.17	+39.59	1.02	1.04	1.10	Accurate
-	Top Fuel	6	45.28	220.88	0.86	+3.02	+32.83	+0.13	+35.99	0.86	0.86	0.89	Not accurate
-	Best Western	6	45.48	219.67	0.85	+3.27	+31.37	+0.12	+34.76	0.86	0.86	0.89	Not accurate
-	W. Dajara	5	44.20	219.96	0.86	+1.58	+29.39	+0.12	+31.09	0.82	0.83	0.86	Not accurate
-	Grat Gun Conan	5	46.03	206.64	0.97	+3.66	+14.49	+0.29	+18.19	0.82	0.83	0.86	Not accurate
-	Domino	10	47.32	199.55	0.74	+6.54	+8.41	0.00	+14.95	0.93	0.94	0.99	Not accurate
-	Red Answer	6	40.13	203.82	0.80	-3.31	+12.23	+0.07	+8.99	0.86	0.86	0.89	Not accurate
3	BBE	44	44.86	195.76	0.74	+3.77	+3.80	0.00	+7.57	1.05	1.06	1.14	Accurate
-	Brinkton	17	45.04	195.01	0.73	+3.67	+2.14	-0.02	+5.80	0.99	1.00	1.06	Doubt
-	KS Sundance	5	38.83	200.04	0.79	-4.55	+7.10	+0.05	+2.60	0.82	0.83	0.86	Not accurate
-	Gandalf	4	43.76	194.91	0.74	+0.97	+1.23	0.00	+2.20	0.78	0.79	0.81	Not accurate
-	Red Density	8	43.29	194.77	0.74	+0.64	+1.45	0.00	+2.09	0.90	0.91	0.95	Not accurate
4	GT Zurita	29	45.32	191.98	0.72	+4.43	-3.10	-0.03	+1.38	1.03	1.04	1.11	Accurate
5	Louis	55	44.79	192.27	0.72	+3.69	-2.65	-0.04	+1.00	1.06	1.07	1.15	Accurate
6	Cham Bravo	24	45.67	190.08	0.70	+4.95	-6.20	-0.07	-1.31	1.02	1.03	1.09	Accurate
-	PFF Evron	16	44.07	191.33	0.72	+2.02	-3.79	-0.03	-1.79	0.98	1.00	1.05	Doubt
7	LXR Major	26	46.11	186.76	0.69	+5.75	-12.04	-0.08	-6.37	1.02	1.04	1.10	Accurate
8	SG Evan	35	44.71	179.72	0.66	+3.42	-25.11	-0.14	-21.83	1.04	1.05	1.12	Accurate
-	Rolex	11	45.84	172.60	0.62	+4.50	-31.06	-0.17	-26.73	0.94	0.95	1.00	Doubt
-	Montana	5	47.24	160.19	0.55	+5.04	-37.48	-0.20	-32.63	0.82	0.83	0.86	Not accurate
9	E Joe Simm	45	43.53	155.93	0.55	+1.32	-69.44	-0.34	-68.47	1.05	1.07	1.14	Accurate
-	Simm Aussy	9	31.53	135.67	0.51	-17.51	-80.72	-0.30	-98.53	0.96	0.93	0.97	Not accurate

BW_C: corrected birth weight (kg); WW_{205}: weaning weight at 205 days of age (kg); ADG: average daily gain (kg/day); N: number of progeny; EBV_{Sire}: estimated breeding value for sire; RA: relative accuracy

Table 4. Top five Simmental calves based on the estimated breeding value of pre-weaning growth traits

Sex	Rank	Calf ID	Bull ID	Dam ID	Date of birth	BW_C (kg)	WW_{205} (kg)	ADG (kg/day)	EBV_{Prog}			
									BW_C	WW_{205}	ADG	Cumulative
Male	1	000354	W. Drovin	PHM 0906	07/12/2012	40.00	302.93	1.28	-1.98	+88.46	+0.38	+86.86
	2	000390	W. Drovin	PKM 0902 SC	09/03/2013	49.35	285.41	1.15	+7.37	+74.26	+0.29	+81.92
	3	000633	Ankonion	0793	09/07/2014	40.00	293.00	1.24	-1.98	+80.76	+0.35	+79.13
	4	000432	W. Drovin	303/160/000127	19/06/2013	46.00	285.50	1.17	+4.02	+74.33	+0.30	+78.65
	5	000434	W. Drovin	D198/B 466	21/06/2013	50.00	276.21	1.10	+8.02	+66.81	+0.25	+75.08
Female	1	000435	W. Drovin	808/0017/000022	22/06/2013	50.40	280.54	1.12	+8.42	+70.32	+0.27	+79.01
	2	000529	Top Fuel	382/516	03/02/2014	54.60	265.61	1.03	+12.62	+58.22	+0.20	+71.04
	3	000447	W. Drovin	509/365	09/07/2013	49.35	265.23	1.05	+7.37	+57.92	+0.22	+65.51
	4	22.05.17	BBE	Diva/Pbm 0018	29/05/2017	56.70	245.68	0.92	+14.72	+42.08	+0.13	+56.93
	5	04.01.16	BBE	808/0017	10/01/2016	50.40	236.28	0.91	+8.42	+34.47	+0.12	+43.00

BW_C: corrected birth weight; WW_{205}: weaning weight at 205 days of age; ADG: average daily gain; EBV_{Prog}: estimated breeding value for progeny

(+0.74 kg) and Bali (+0.46 kg) calfs (Atil *et al.*, 2005; Intaratham *et al.*, 2008; Hilalah *et al.*, 2018). Thus, the EBV_{Prog} for WW in this study were +88.46 (Calf ID: 000354) and shows higher than Friesian Holstein (+5.11 kg) and Northeastern Thai (+4.17 kg) calfs (Atil *et al.*, 2005; Intaratham *et al.*, 2008). In this study, total of nine bulls (38%) were selected based on the RA value. Bulls with RA value more than 1.00 in each progeny traits were selected to maintain in the breeding program. Hence, bulls with RA value less than 1.00 must be evaluated with more records data of their progeny traits.

CONCLUSION

The h^2 values of BW_C, WW_{205} and ADG in animals study were included of high category. Therefore, selection of Simmental cattle in this study can be performed based on those traits. However, the weaning weight was recommended as selection criteria because of highly genetic correlation to yearling weight. In addition, nine the best bulls that obtained in this this study can be used as the breeding bulls, because these bulls had highly selection accuracy.

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REFERENCES

Abera, H., Abegaz, S. and Mekasha, Y. 2013. Influence of non-genetic factors on growth traits of Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle. *Glob. J. Anim. Bred. Genet.* 1 : 31-36.

Addisu, B., Taye, M., Kebede, A., Mekuriaw, G., Tassew, A., Mulugeta, T. and Goshu, G. 2010. Milk yield and growth performance of cattle under partial suckling system at Andassa Livestock Research Centre, North West Ethiopia. *Livest. Res. Rur. Develop*. 22.

Afroz, M.A., Haque, M.A. and Bhuiyan, A.K.F.H. 2011. Estimation of heritability for growth traits of Red Chittagong cattle in a nucleus herd. *Bang. Vet*. 28: 39-46.

Atil, H., Khattab, A.S. and Badawy, L. 2005. Genetic parameter of birth and weaning weights for Friesian calves by using an animal model. *Arch. Tierz*. 48: 261-269.

Bakir, G., Kaygisiz, A. and Ulker, H. 2004. Estimates of genetic and phenotypic parameters for birth weight in Holstein Friesian cattle. *Pak. J. Biol. Sci.* 7 : 1221-1224.

Becker, W.A. 1993. *Manual of Quantitative Genetics*, 5th Ed. Academic Enterprises Valllman, Washington.

El-Saied, U.M., de la Fuente, L.F., Rodriguez, R. and san Primitivo, F. 2006. Genetic parameter estimates birth and weaning weights, pre-weaning daily gain and three type traits for Charolais beef cattle in Spain. *Spain. J. Agric. Res*. 4 : 146-155.

Falconer, D.S. and T.F.C. Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman Group Ltd, England.

Gunawan, A and Jakaria. 2011. Genetic and non-genetic effects on birth, weaning and yearling weights of Bali cattle. *Media Peternakan*. 34:93-98.

Ebangi, A.L., Erasmus, G.J., Tawah, C.L. and Mbah, D.A. 2002. Genetic trends for growth in selection experiment involving purebred and two-breed synthetic beef breed in a tropical environment. *Revue Ìlev. Mëd. Vët. Plays Trop*. 55 : 305-312.

Hardjosubroto, W. 1994. Aplikasi Pemuliaan Ternak di Lapangan. Gramedia Widiasarana, Jakarta.

Hartati, Muladno, Jakaria, R. Priyanto, A. Gunawan, Aryogi and C. Talib. 2015. Heritability estimation of and non-genetic factors affecting production traits of Indonesian Ongole cross. *JITV*. 20 : 168-174.

Hilalah, N., Ardika, I.N. and Warmadewi, D.A. 2018. The estimation of breeding value of Bali cattle body weight at Balai Pembibitan Ternak Unggul dan Hijauan Pakan Ternak (BPTU-HPT) Denpasar. *Pet. Trop*. 6 : 1-11.

Intaratham, W., Koonawootrittriron, S., Sopannarath, P., Graser, H.U. and Tumwasorn, S. 2008. Genetic parameters and annual trends for birth and weaning weights of a Northeastern Thai indigenous cattle line. *Asian-Aust. J. Anim. Sci*. 4: 478-483.

Karnaen. 2008. Estimation heritability, genetic and phenotypic correlations of body weight traits in Madura cattle. *J. Indon. Trop. Anim. Agric*. 33 : 191-196

Kaswati, Sumadi and Ngadiyono, N. 2013. The heritability estimation of birth weight, weaning weight of Bali cattle at Balai Pembibitan Ternak Unggul Sapi Bali. *Buletin Peternakan*. 37: 74-78.

Pattie, W. A. and James, J.W. 1985. *Principle of Applied Animal Breeding*. Department of Animal Breeding. University of Queensland, Queensland.

Prihandini, P.W., Maharani D., Suparta, G. and Sumadi. 2018. Estimates of heritability and breeding values for growth traits in Madura cattle reared in Pamekasan Regency. *Asian Jr. of Microbiol. Biotech. Env. Sc.* 20 : 1041-1044.

Putra, W.P.B., Sumadi, Hartatik, T. and Saumar, H. 2015. Evaluation of growth traits of Aceh cattle at the breeding station in Indrapuri District of Indonesia. *Bang. J. Anim. Sci.* 44 : 85-91.

Putra, W.P.B., Agung, P.P. and Said, S. 2018. Non-genetic factor and genetic parameter analysis for growth traits in Sumba Ongole (SO) cattle. *J. Indonesian Trop. Anim. Agric.* 43 : 94-106.

Rahman, S.M.A., Bhuiyan, M.S.A. and Bhuiyan, A.K.F.H. 2015. Effects of genetic and non-genetic factors on growth traits of high yielding dairy seed calves and genetic parameter estimates. *J. Adv. Vet. Anim. Res*. 2: 450-457.

Rakwadi, E., Nsoso, S.J., Gondwe, T.N. and Banda, J.W. 2014. Estimates of phenotypic and genetic parameters and responses to selection in growth traits in three beef cattle breeds raised under ranch conditions in Botswana. *Bots. J. Agric. Appl. Sci*. 10.

Raphaka, K. 2008. Estimation of Genetic and Non-Genetic Parameters for Growth Traits in Two Beef Cattle Breeds in Botswana. Thesis. University of Stellenbosch, Stellenbosch, South Africa.

Rastosari, A., Sumadi dan Hartatik, T. 2014. Estimasi nilai pemuliaan (NP) sapi Brahman di BPTU-HPT Sembawa, Sumatera Selatan. Prosiding Seminar Nasional Biodiversitas V. Surabaya, 6 September 2014. pp. 250-253.

Regatieri, I.C., Boligon, A.A., Baldi, F. and Albuquerque, L.G. 2012. Genetic correlations between mature cow weight and productive and reproductive traits in Nellore cattle. Genet. Mol. Res. 11: 2979-2986.

Said, S., Agung, P.P., Putra, W.P.B., Anwar, S., Wulandari, A.S. and Sudiro, A. 2016. Selection of Sumba Ongole (SO) cattle based on breeding value and performance test. *J Indonesian Trop. Anim. Agric.* 41: 175-187.

Sarmiento, R.M. and Garcia, J.P. 2007. Estimation of genetic parameters and variance components for growth traits in Romosinuano cattle in the Colombian humid tropic. *Genet. Mol. Res*. 6: 482-291.

Sumadi, Fathoni, A., Maharani, D., Ngadiyono, N., Widayati, D.T., Noviandi, C.T. and Khusnudin, M. 2017. Breeding value of sires based on offsprings weaning weight as a recommendation for selecting Kebumen Ongole grade cattle. *J Indonesian Trop. Anim. Agric.* 42 : 160-166.

Soeparno. 2005. *Ilmu dan Teknologi Daging*. 4th Ed. Gadjah Mada University Press, Yogyakarta.

Supriyantono, A., Hakim, L., Suyadi dan Ismudiono. 2010. Evaluasi pejantan sapi Bali berdasarkan sifat pertumbuhan menggunakan metode Animal Model. *Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner Tahun 2010. Bogor, 3-4 Agustus 2010.* pp. 9-16.

Supriyantono, A., Hakim, L., Suyadi and Ismudiono. 2011. Breeding programme development of Bali cattle at Bali Breeding Centre. *Animal Production*. 13: 45-51.

Tumwasorn, S. 1997. Breeding value estimation of birth weight in beef cattle at Loongchow farm in Supanburi province. *AGRIS.* (Abstr.)

Warwick, E.J., Astuti, J.M. and Hardjosubroto, W. 1990. *Pemuliaan Ternak.* Gadjah Mada University Press, Yogyakarta.